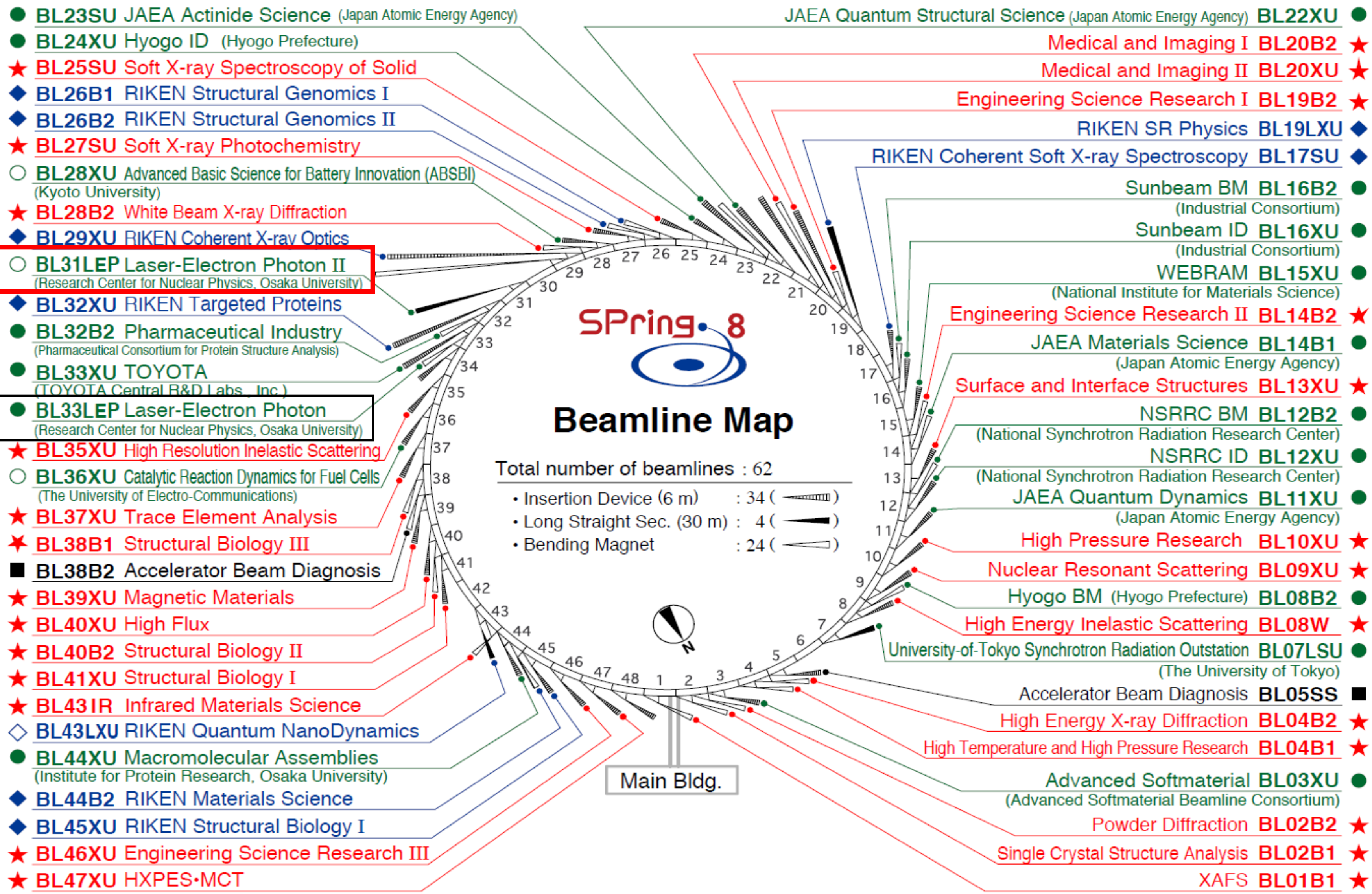
LEPS2: the second Laser-Electron Photon facility at SPring-8

RCNP M. Yosoi

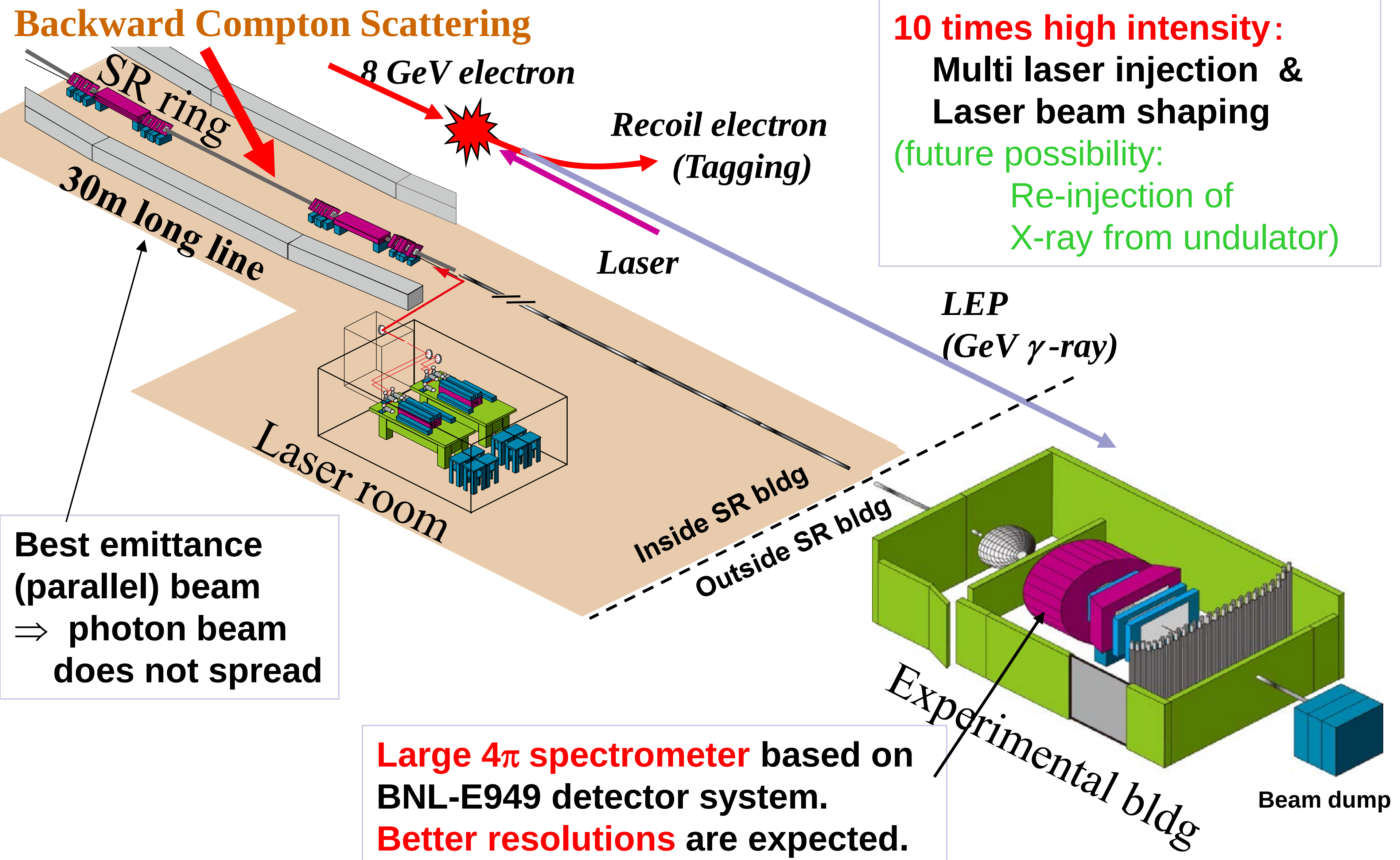
- How to increase the LEP intensity
- Design of the main detector system
- Polarized HD target

Beam line map of Spring-8



~60 BL's: atomic and molecular physics, material, biological and medical science engineering, Industrial use, etc.

Schematic view of the LEPS2 facility

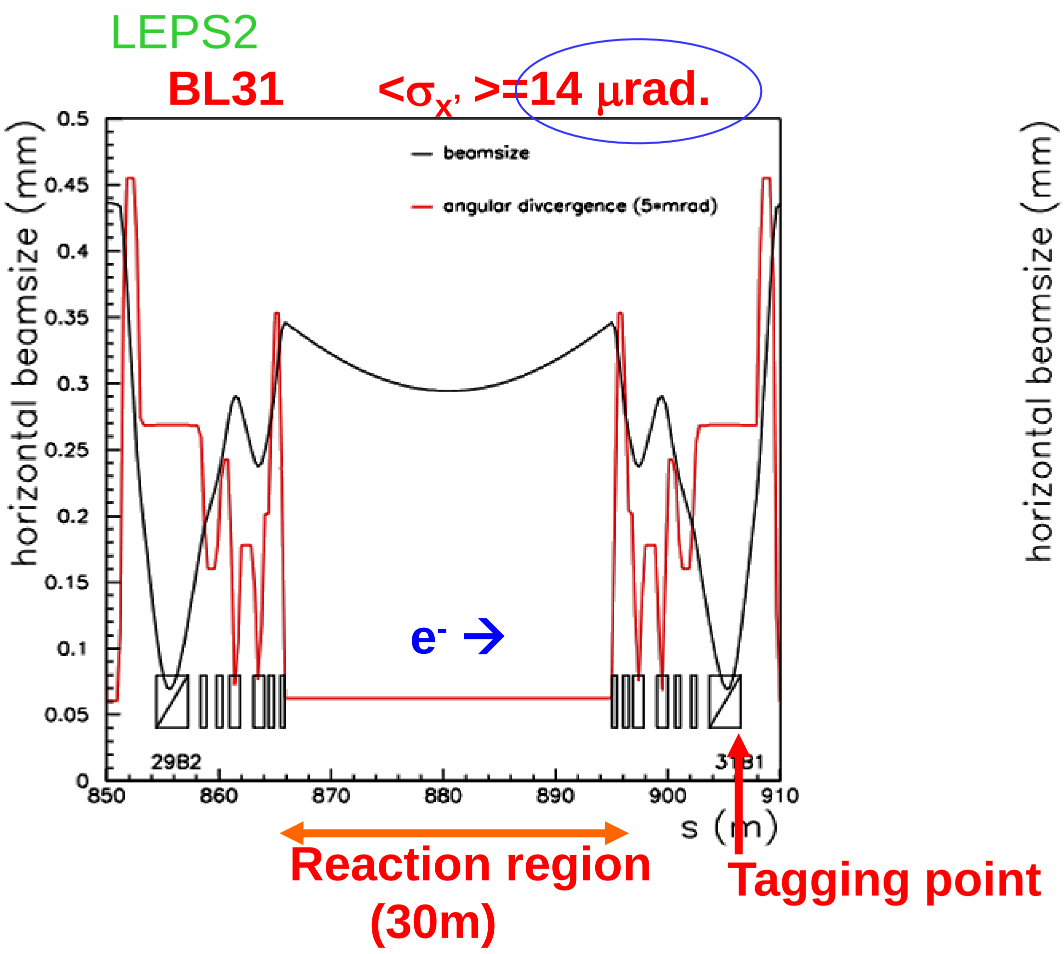


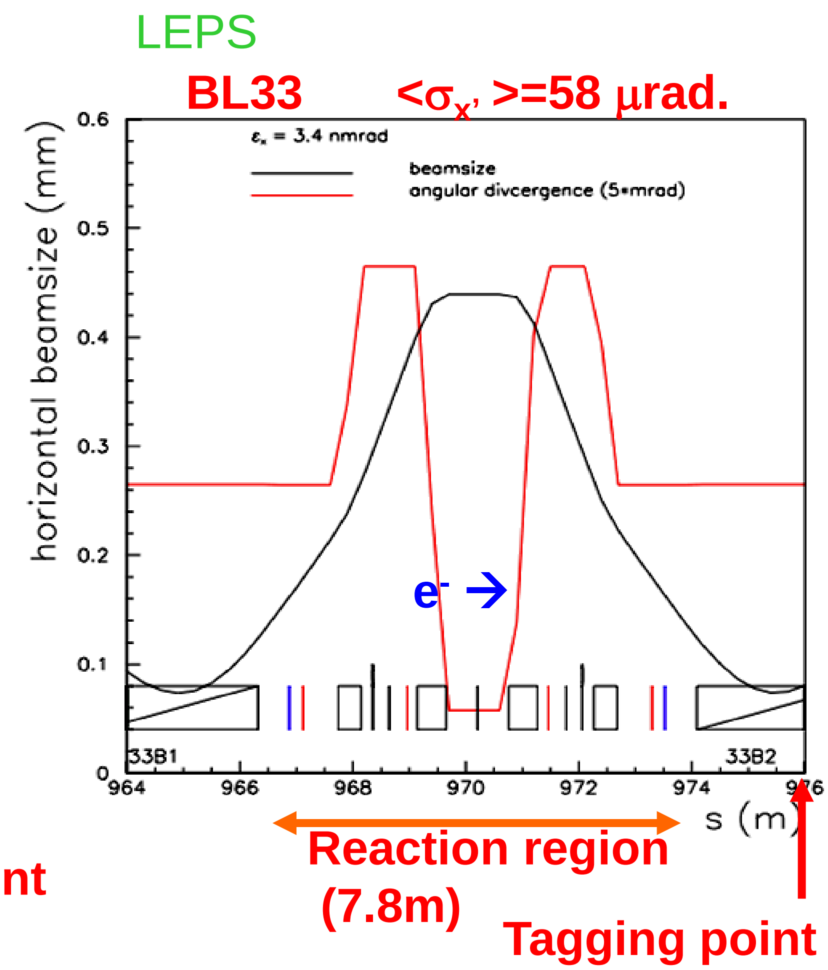
10 times high intensity:
Multi laser injection &
Laser beam shaping
(future possibility:
Re-injection of
X-ray from undulator)

Best emittance (parallel) beam
⇒ photon beam does not spread

Large 4π spectrometer based on BNL-E949 detector system.
Better resolutions are expected.
New DAQ system will be adopted

Divergence of LEP beam





Better divergence → Better tagging resolution
Smaller beam size at long distance

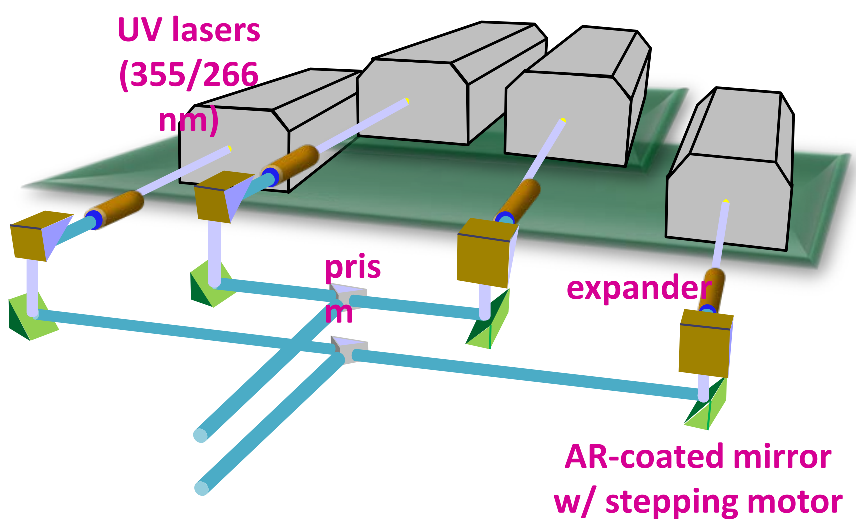
How to get the high Intensity Photon Beam

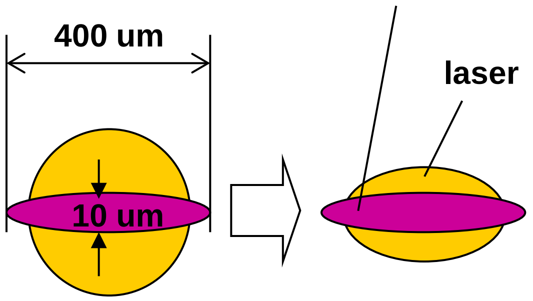
We are aiming to produce one-order higher intensity photon beam :

LEP intensity ≥ 10^7 cps for E_γ<2.4 GeV beam (355 nm)

≥ 10^6 cps for E_γ<2.9 GeV beam (266 nm)

- Simultaneous injection of 4-lasers [x4]
- Higher output power and lower power consumption CW lasers.
  355 nm (for 2.4 GeV) 8 W→16 W, 266 nm (for 2.9 GeV) 1 W→2 W [x2]
- Laser beam shaping with cylindrical expander [x2]

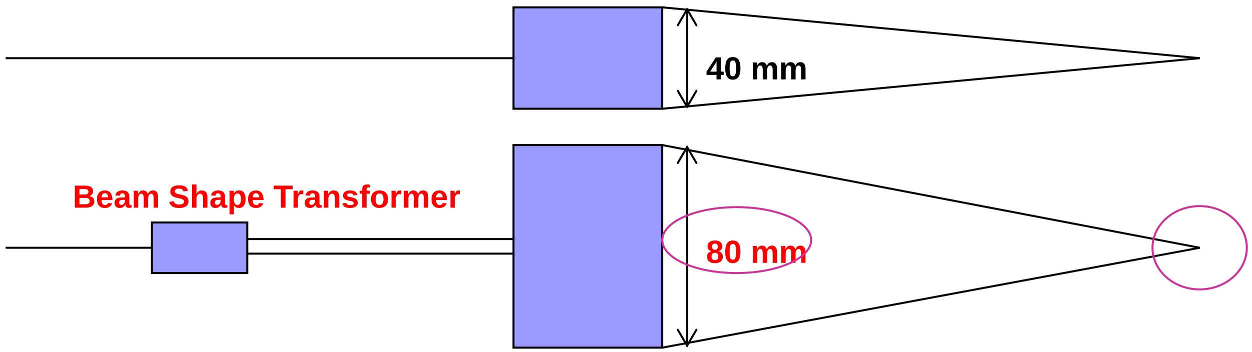


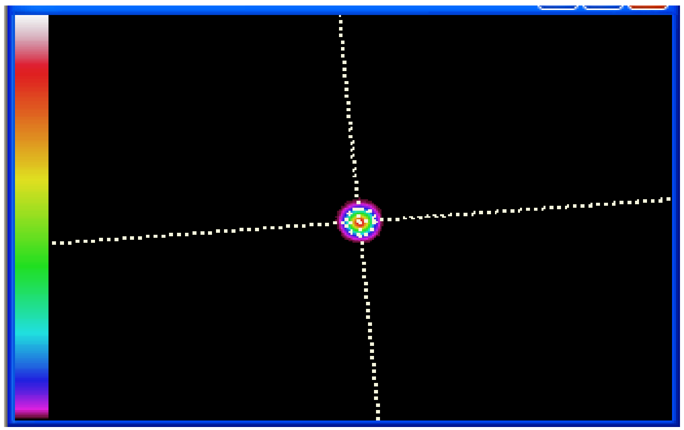


- Electron beam is horizontally wide.
  ⇒ BCS efficiency will be increased by elliptical laser beam.

Need large aperture of the laser injection line → reconstruct some BL chambers

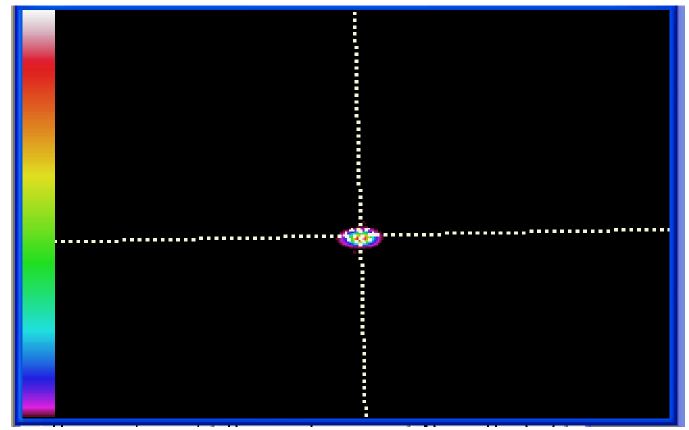
Test of Laser Beam shaping with visible wavelength laser

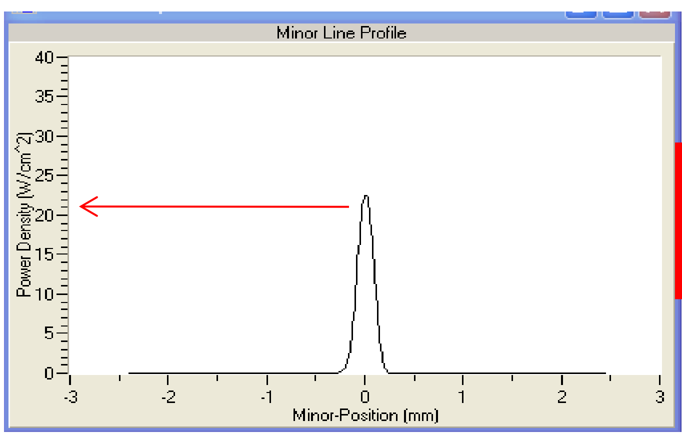




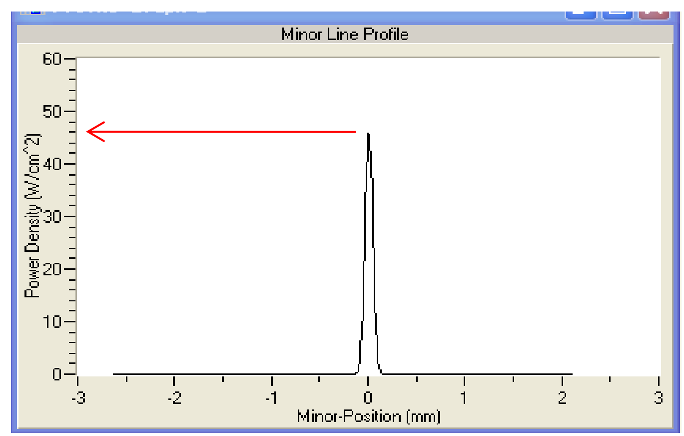
normal expander

cylindrical expander





Power density gets twice.



Design concepts of Main Detector

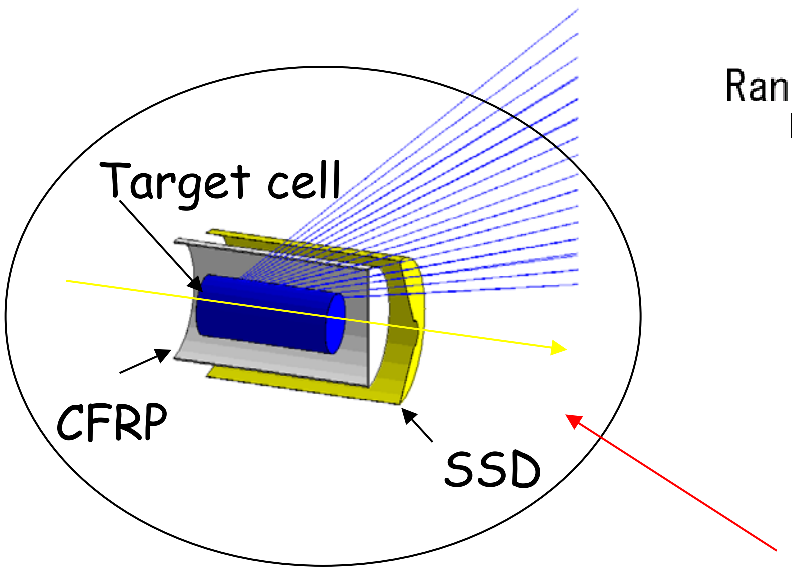
- Momentum resolution at forward angle $\Delta p/p \sim 1\%$.

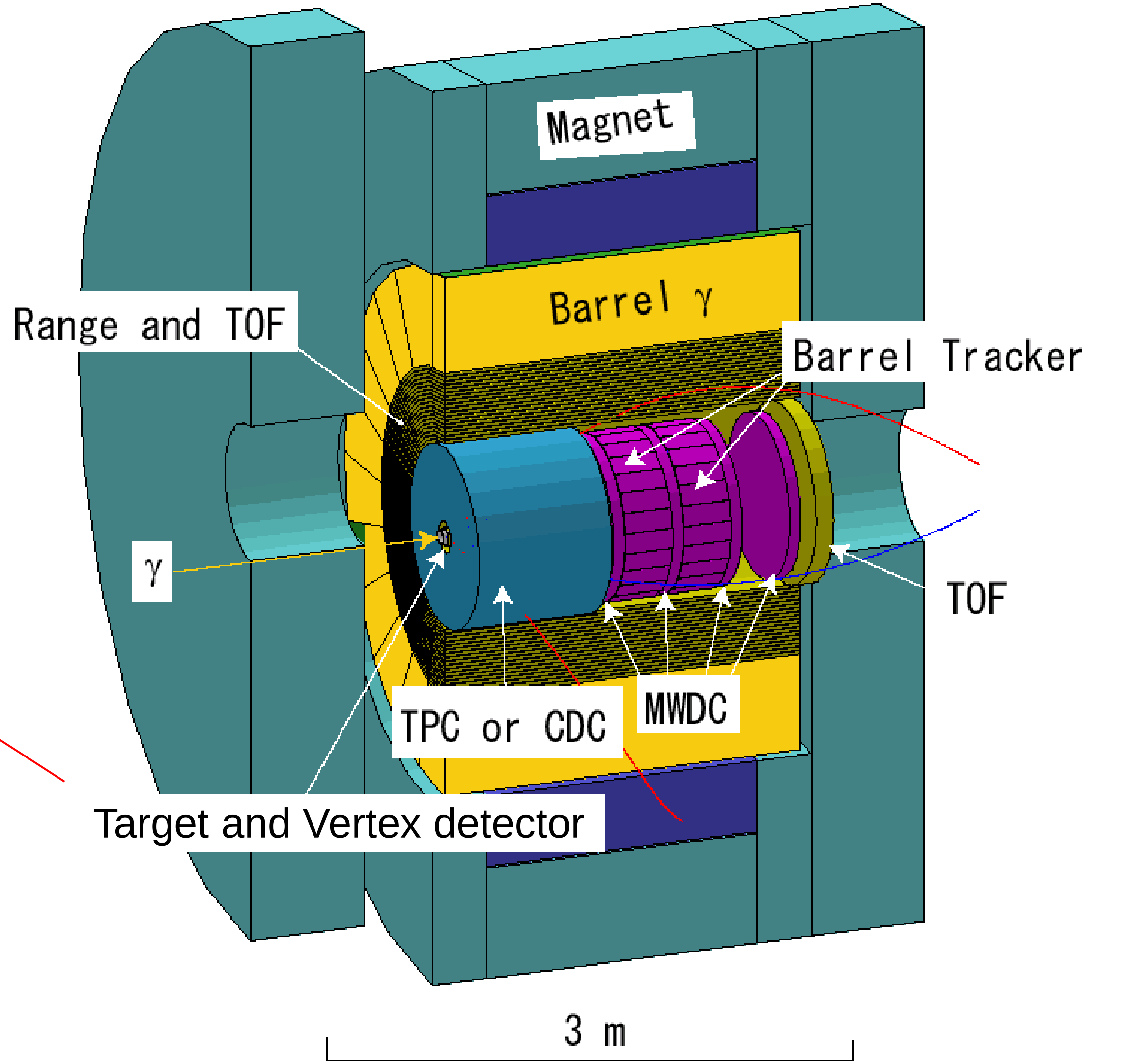
  → Good reaction tag.
- Large and smooth acceptance azimuthally → Decay and polarization.
- Detection of decay product down to lower momentum 100 MeV/c
- Detection of neutral particle (Photon)

Main Detector Setup

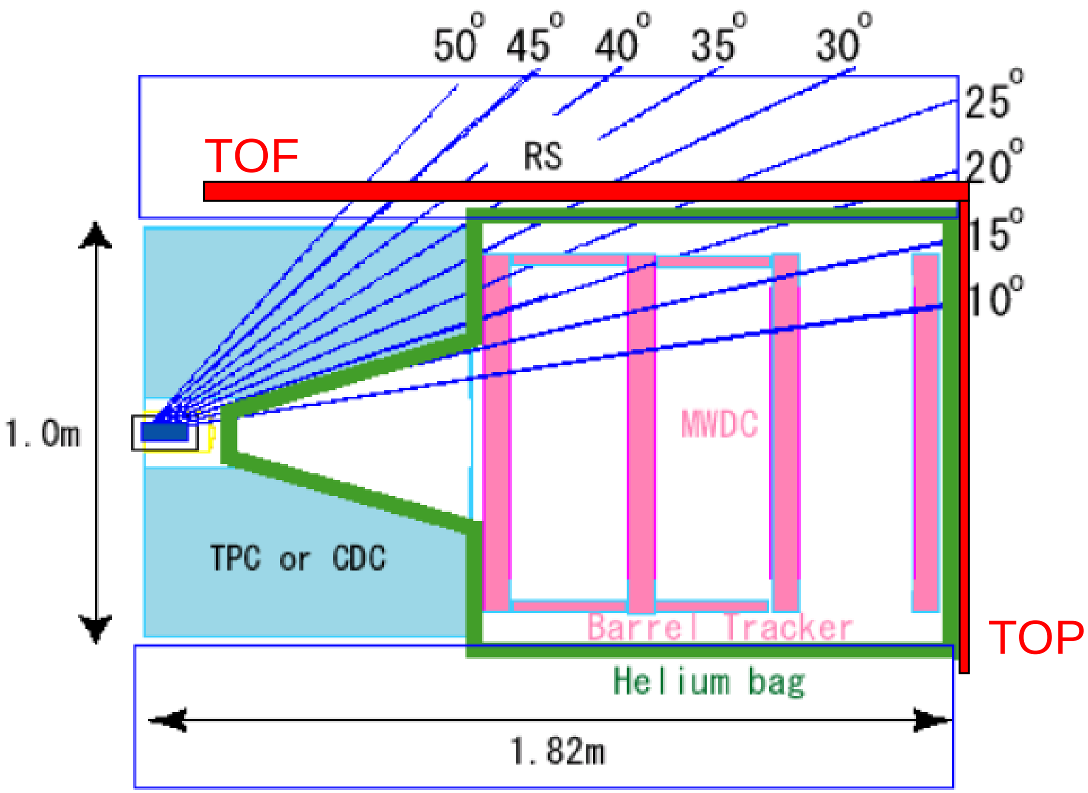
E949 Solenoid Magnet

size: ϕ5m × 3.5m
weight: ~400 t
Field: 1.0 T





Tracking system



- Side way tracker (TPC)
  R = 500 mm (24-26 layer),
  $\sigma_{r\phi}$ =150um, σ_z =2mm,
- Forward MWDC chamber(450mm)
  ^{4}He+Ethane (X/X_0 = 1.1x10^{-3})
  6 plane (x,x', u(45) u'(-45), y y')
  σ_{xy} =**150um,**
- Barrel tracker
  Cathode strip + Anode wire
  $\sigma_{r\phi}$ = 250um, σ_z = 2-3 mm
- SSD (Cylindrical+ Disk)
  Double side strip sensor
  σ=35um,
  ΔZ< 1 mm at θ>20^0

- PID
  sideway: TOF (Δt =50 psec)
  forward: TOP (quarts Cerenkov)

Penta-quark Θ^+

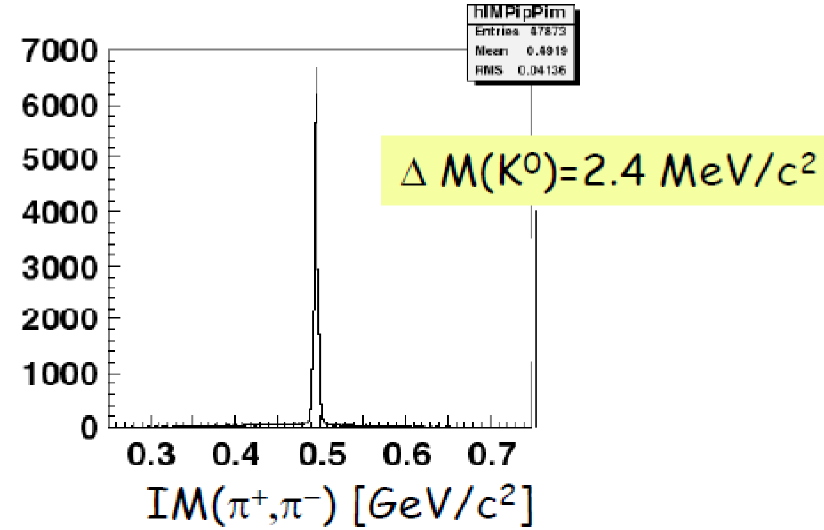
Strangeness tagging

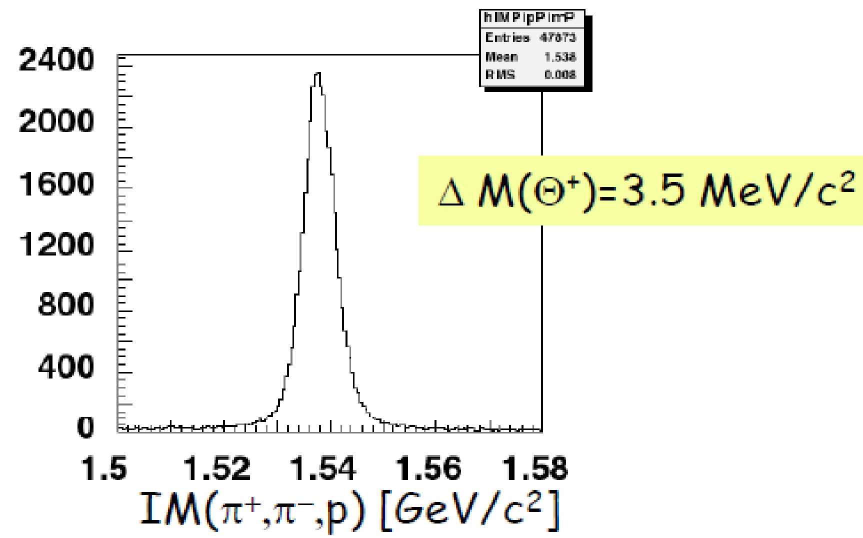
$$\gamma + n \rightarrow K^- + \Theta^+$$

$$\rightarrow p \; K^0$$

$$\rightarrow \pi^+ \pi^-$$

Invariant Mass measurement



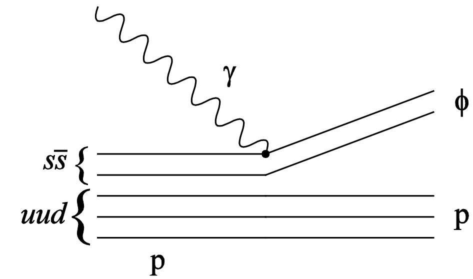


Polarized HD Target

- We have developed the polarized HD target for these 6 years.

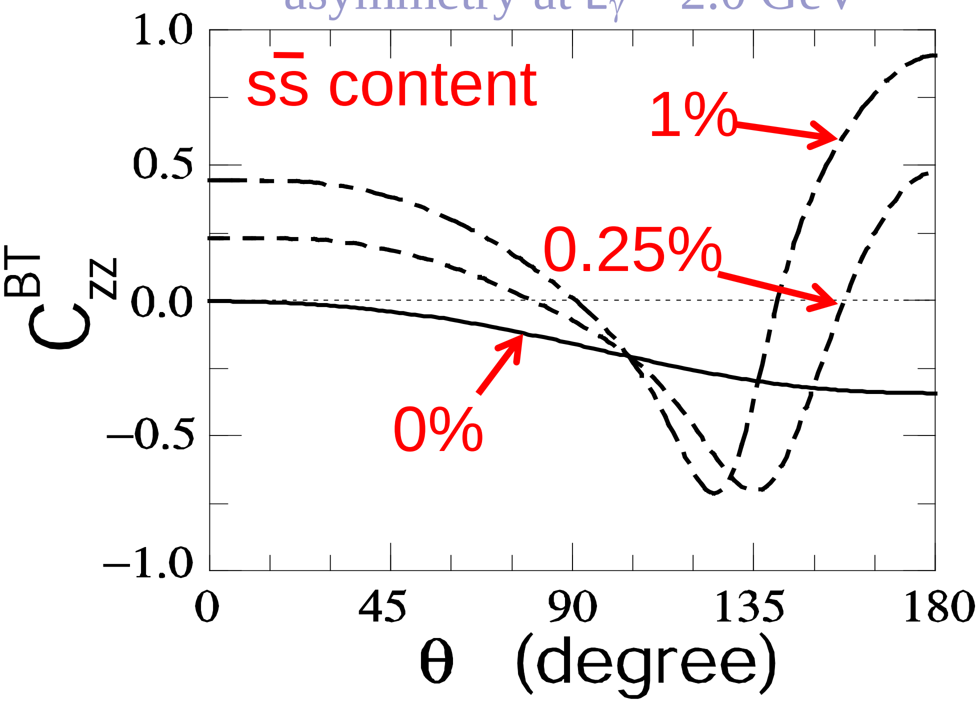
- The proposed experiment is the measurement of the double polarization asymmetry of the ϕ photoproduction, which is sensitive to the ss-bar content in nucleon through the ss-bar knockout process.
  (A.I.Titov et al. PRC58(1998)2429)

- When we succeed the development and establish its technology, it will be a strong weapon at LEPS2.



$s\bar{s}$-knockout

Beam-Target double spin asymmetry at E_γ = 2.0 GeV

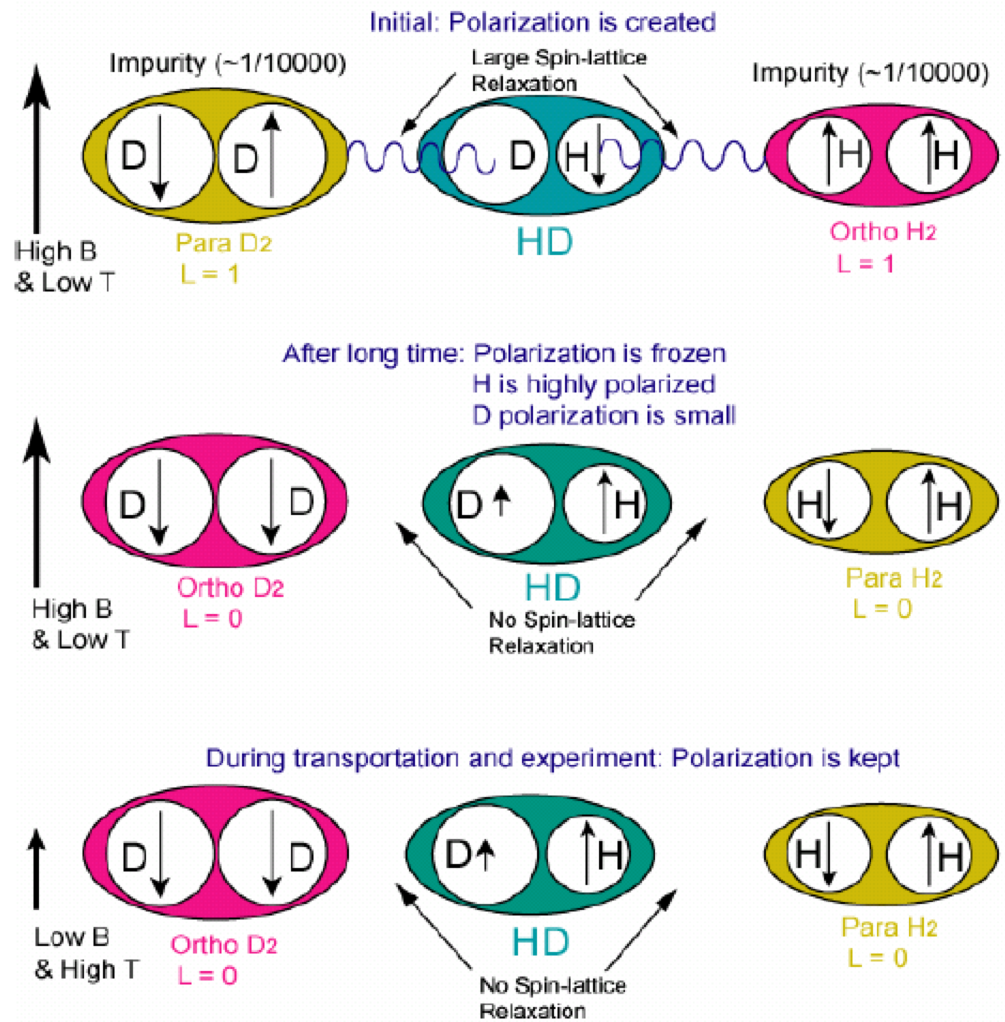


Principle of polarized HD

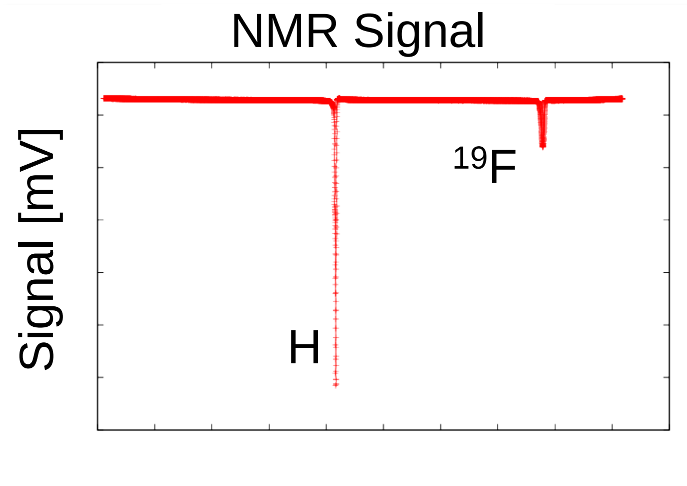
H and D are polarized by the static method, i.e., using the thermal equilibrium under the ultra low temperature and high magnetic field.

Special advantage:
After a few months aging time, spin is frozen, even under high temperature and low magnetic field.

- Longstanding effort at Syracuse, LEGS/BNL, ORSAY
- 10-20 mK
- 15-17T
- >80% for H, >20% for D (vector)
- 20%→70% in D with DNP

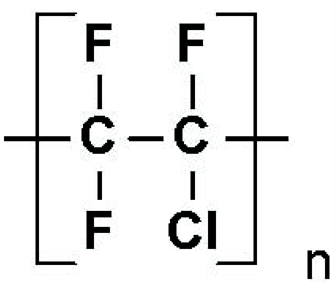


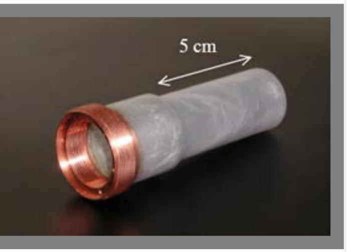
NMR signals after 53-day aging

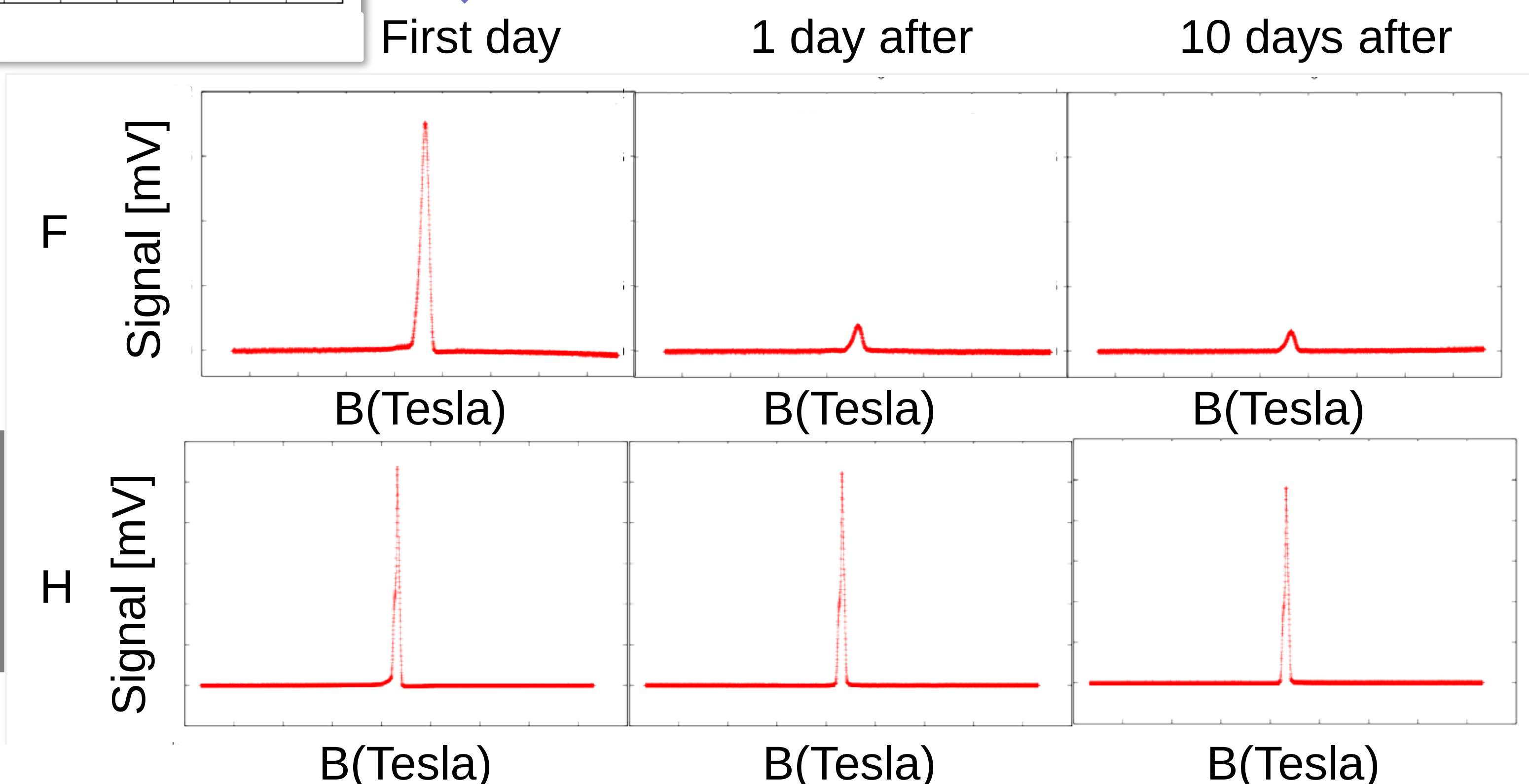


The first NMR spectra of polarized HD target.
Aging time is 53 days under 17 T and 14 mK.

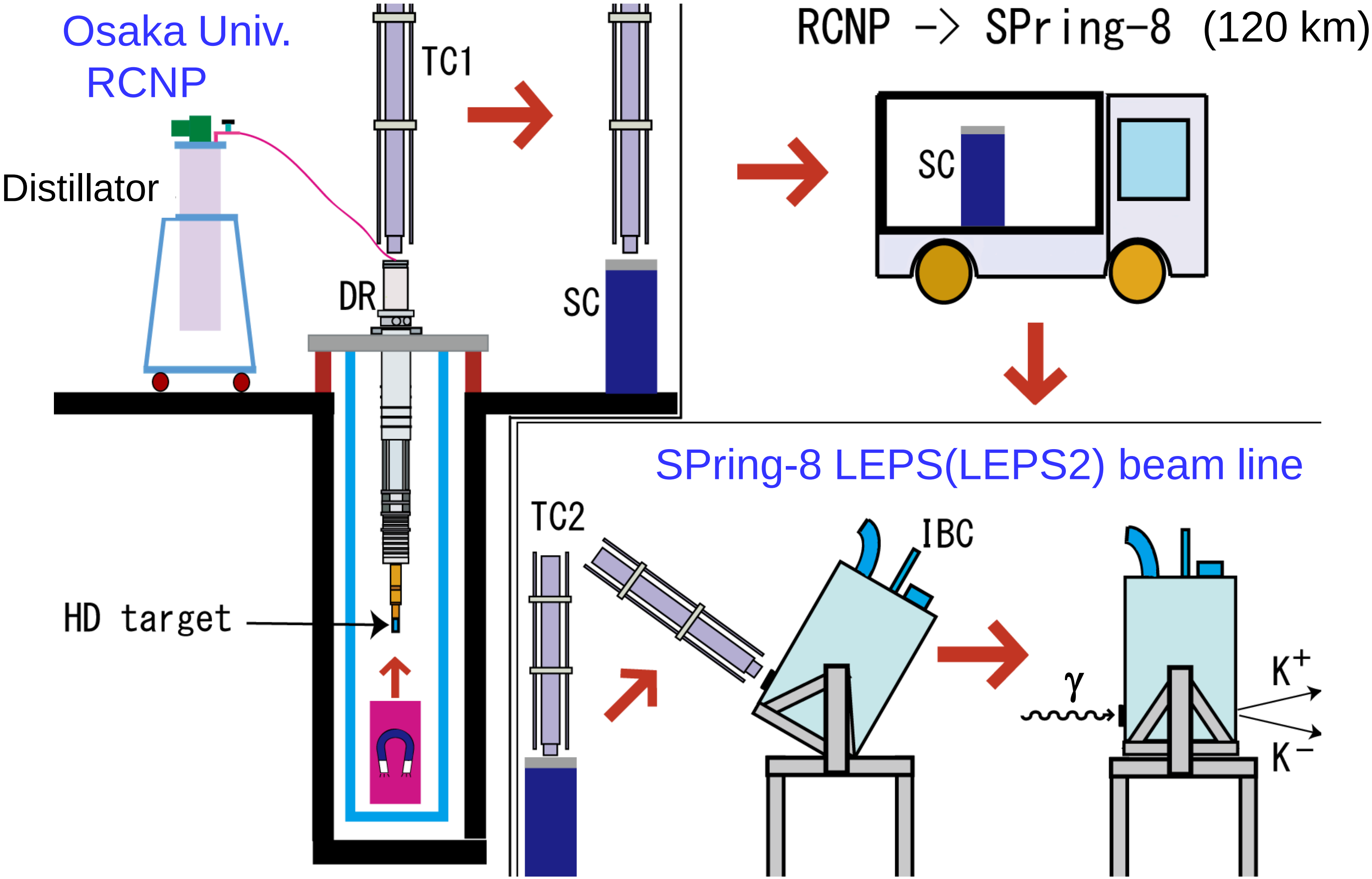
- As a result, relaxation time is more than 100 days at 300 mK and 1 T.







Process to use in the experiment



DR: Dilution Refrigerator

TC1(2): Transfer Cryostat

SC: Storage Cryostat

IBC: In-Beam Cryostat

Dilution Refrigerator (DR)

17 T Magnet

Transfer Cryostat @RCNP (TC1)

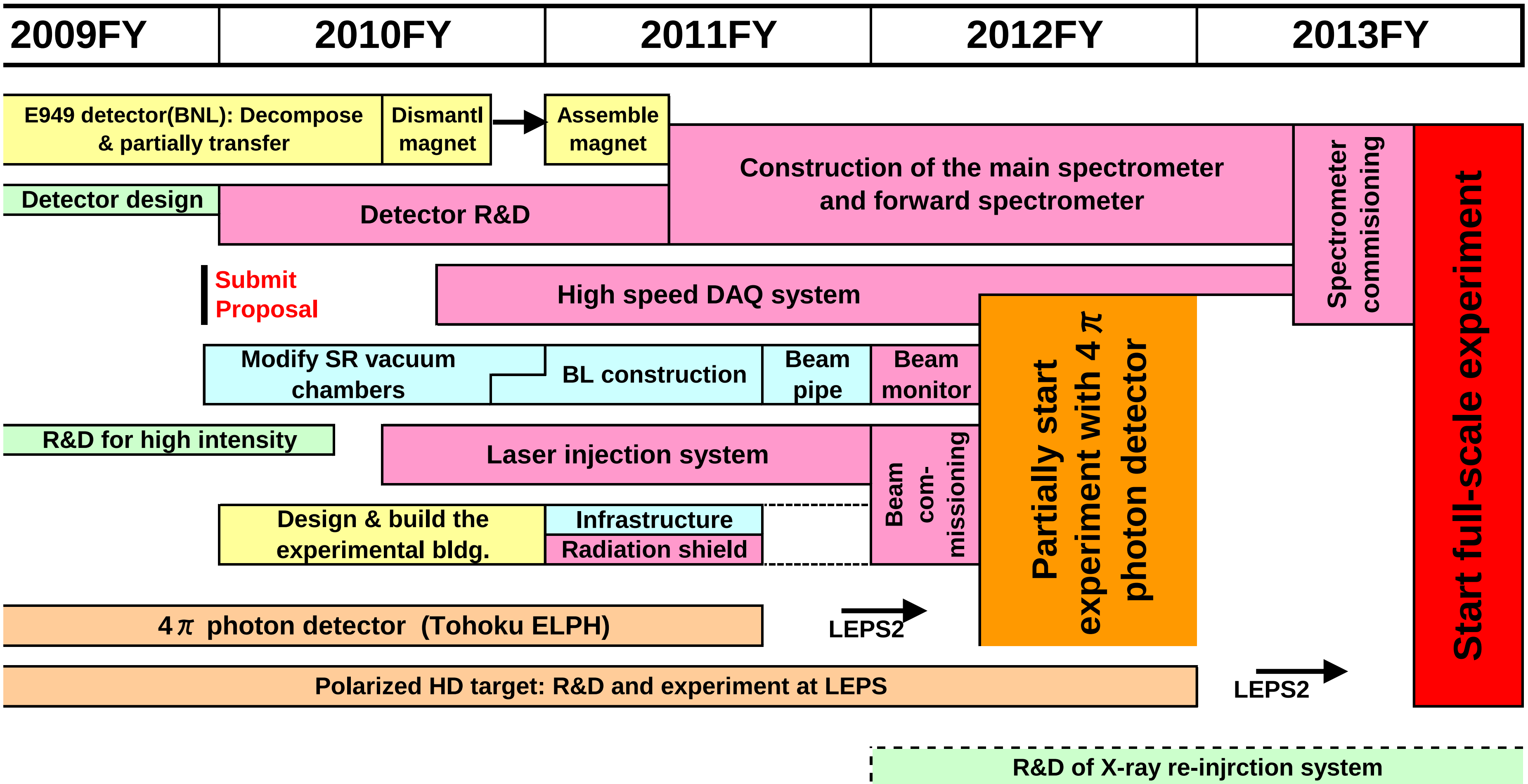
Transfer Cryostat @SP8

(TC2)

Storage Cryostat (SC)

In-Beam Cryostat (IBC)

LEPS2 roadmap



We need to get more budget and widen the collaboration.

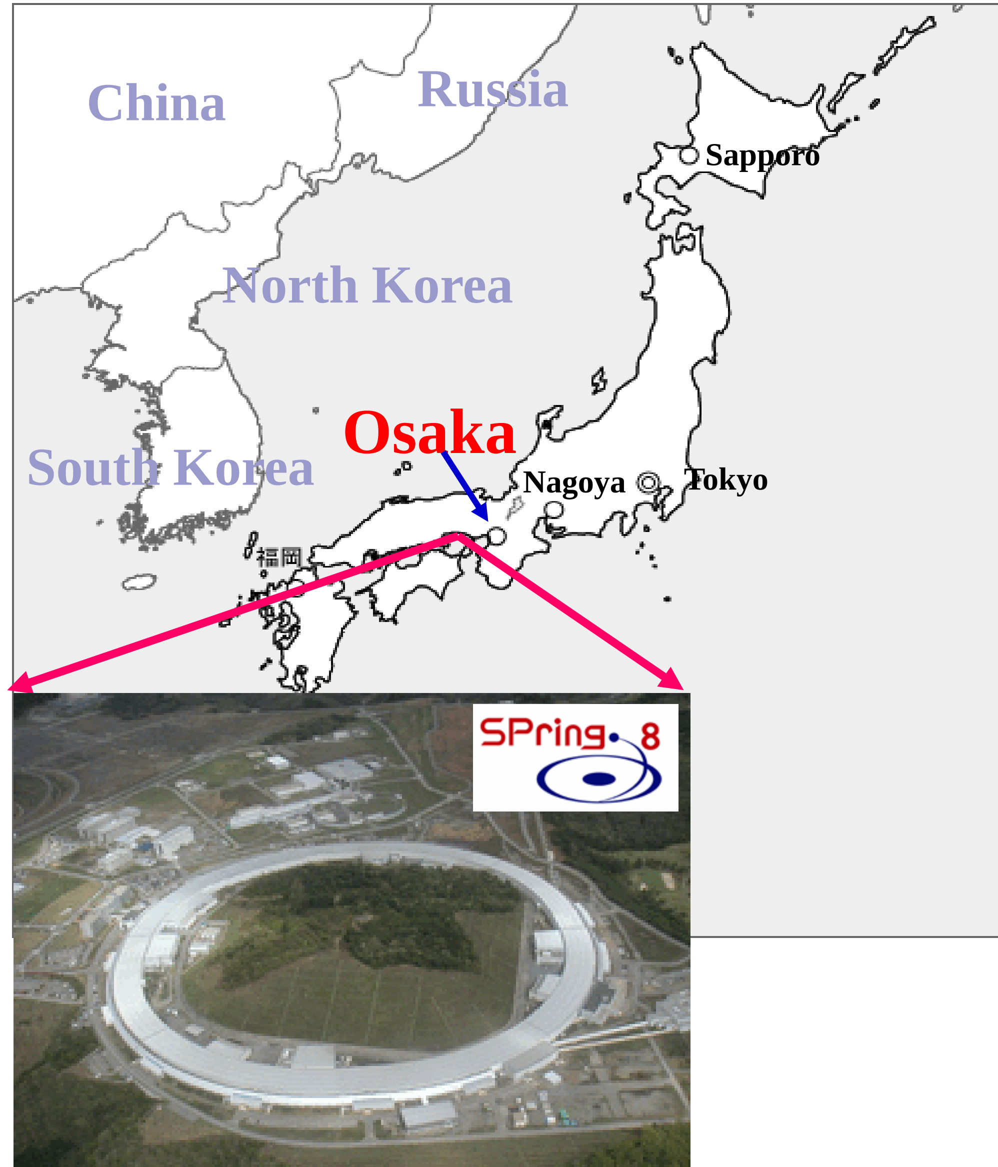

2010.10.11


2010.12.10

Backup

Super Photon ring – 8 GeV

- 8 GeV electron beam
- Diameter ≈457 m
- RF 508 MHz
- One-bunch is spread within $\sigma = 12$ psec.
- Beam Current = 100 mA
- Top-up injection



Osaka – SPring-8: about 120 km,
One and half an hour highway drive.

LEPS new beam line (LEPS2)

- Beam upgrade:

  Intensity --- High power laser, Multi laser(x4)

  --- Laser elliptic focus

  $\sim 10^6 \rightarrow \sim 10^7$ /sec for 1.5 GeV~2.4 GeV

  $\sim 10^5 \rightarrow \sim 10^6$ /sec for 1.5 GeV~2.9 GeV

  (Energy --- Laser with short λ ,

  re-injected Soft X-ray+BCS (future possibility), → up to ~7.5 GeV)

- Detector upgrade: (reaction process & decay process)

  Scale & Flexibility --- General-purpose large 4π detector → large experimental hutch

  Coincidence measurement of charged particles and neutral particles (photons) ← BNL/E949 detector

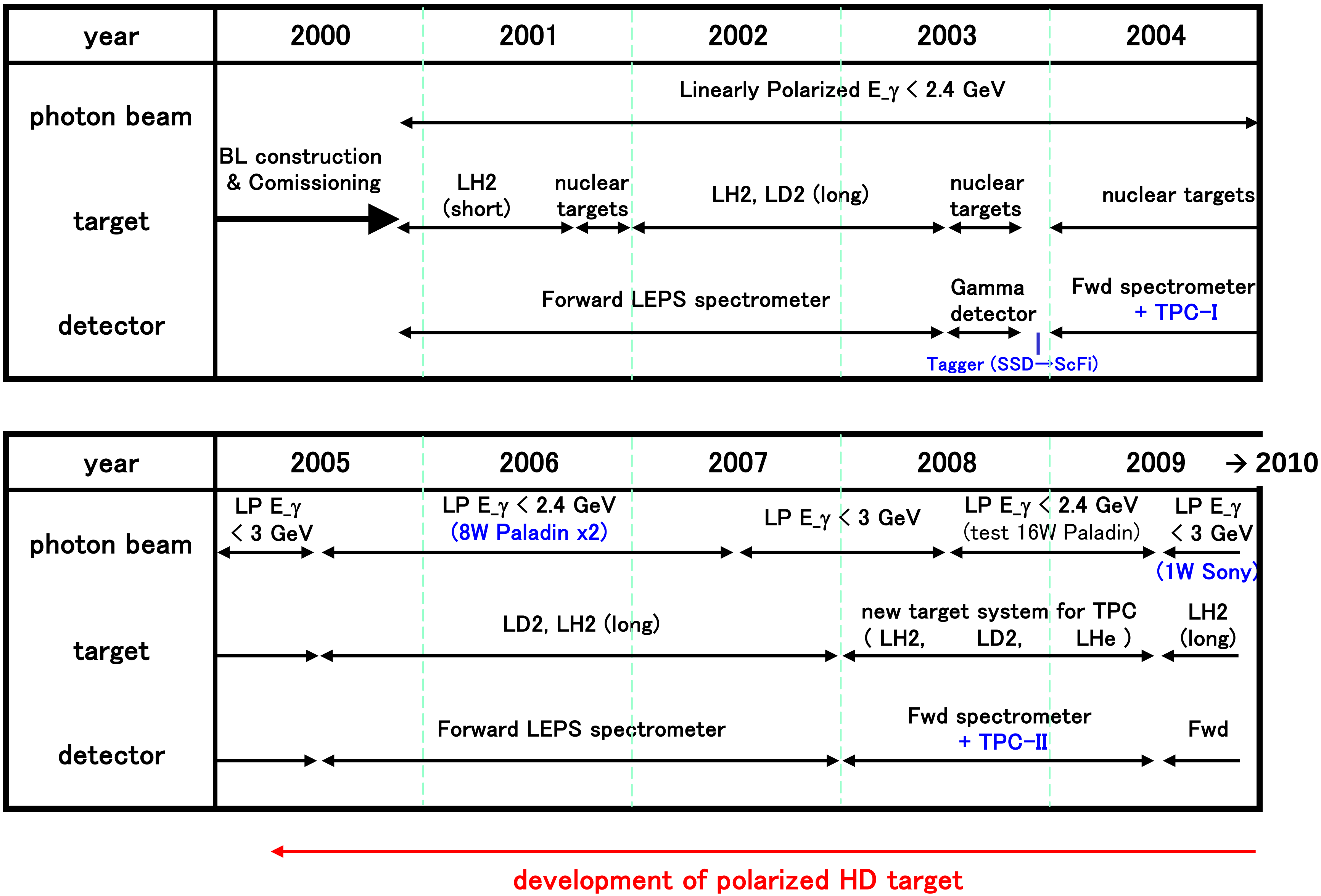
  DAQ --- High speed for the minimum bias trigger

- Target upgrade: Polarized HD target

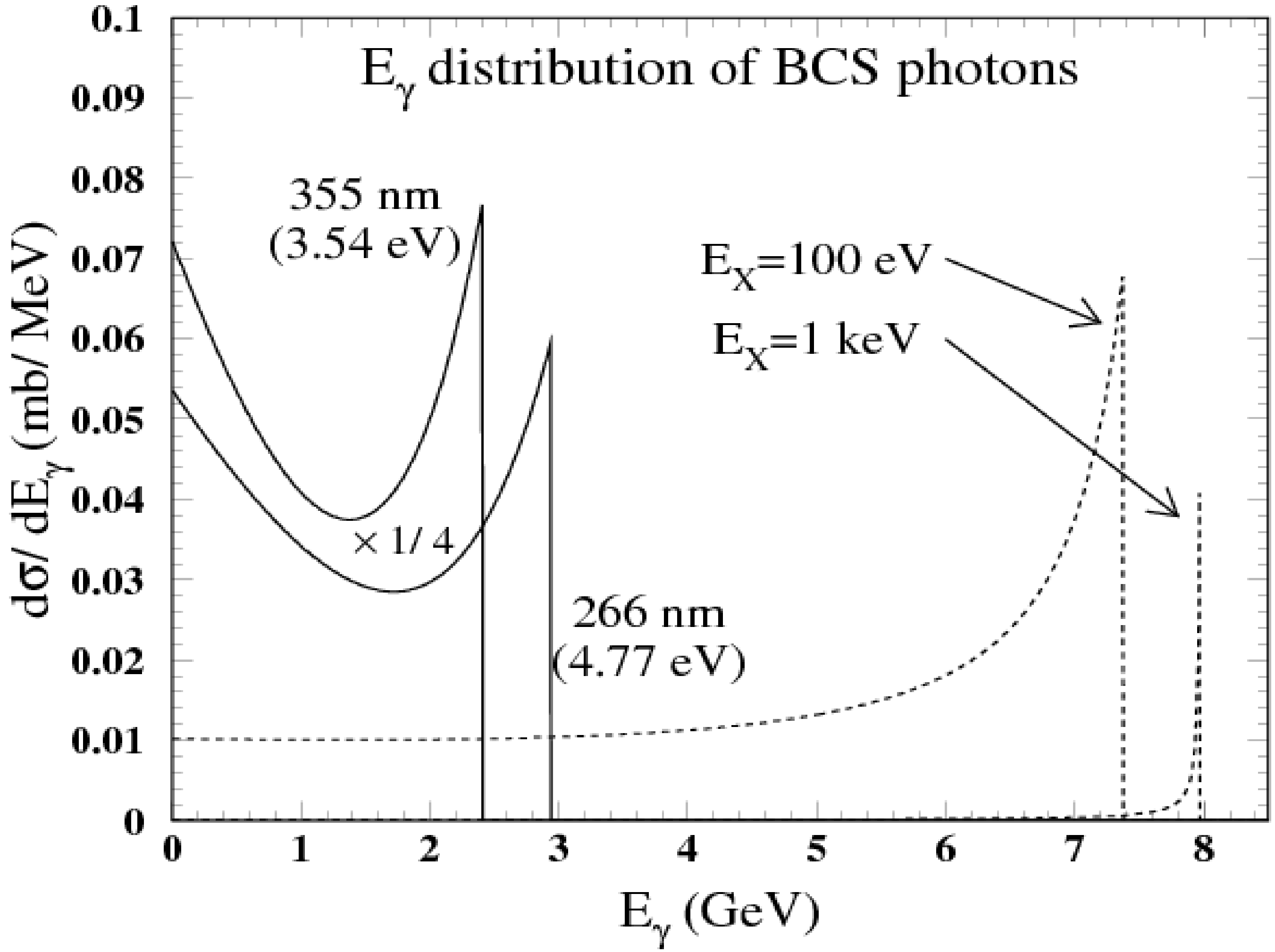
- Physics: Continuous study from LEPS (e.g. Θ^+), new Physics

  Workshop on LEPS2 (2005/7, 2007/1)

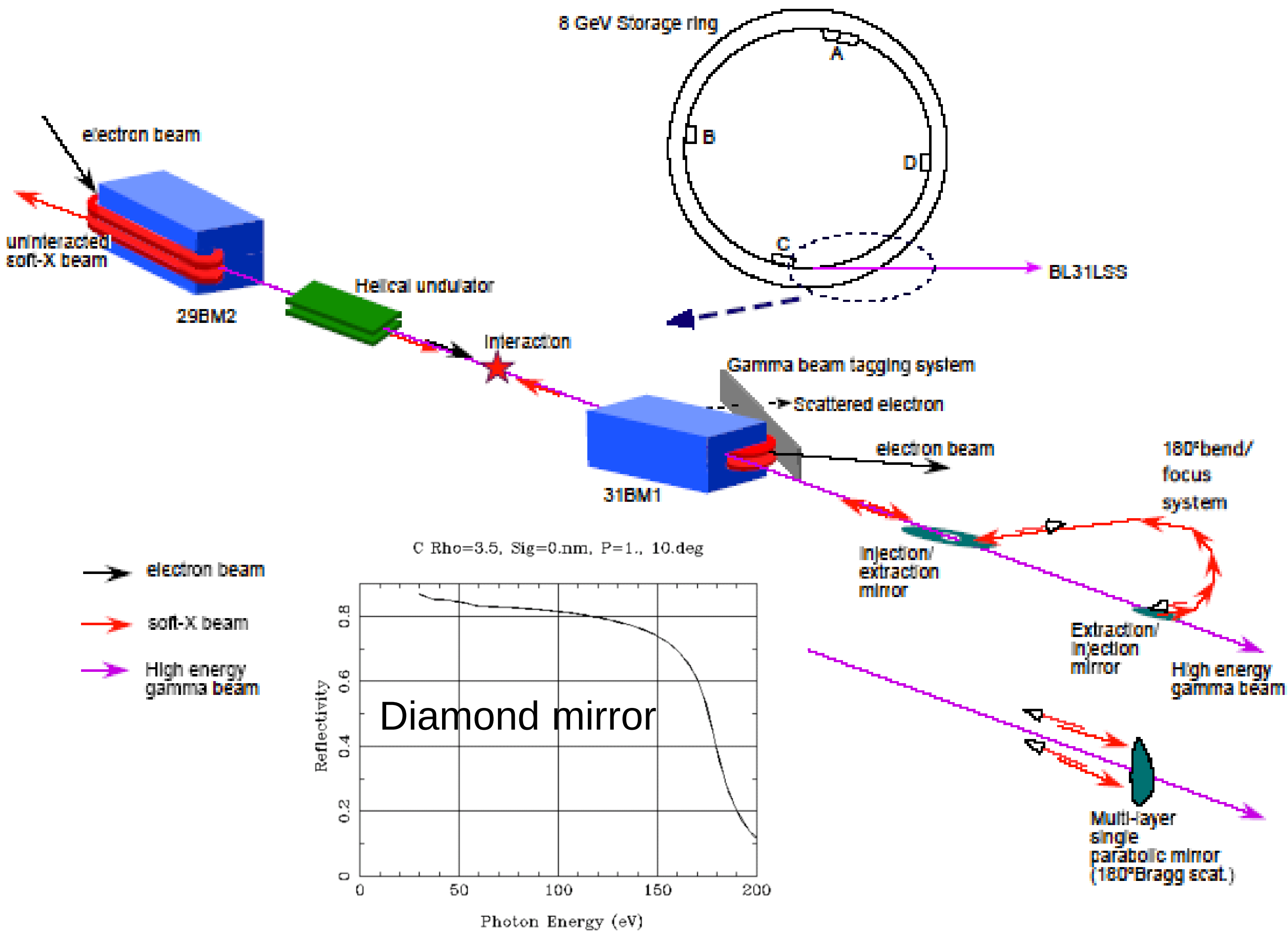
LEPS experiments (2000 – 2010)



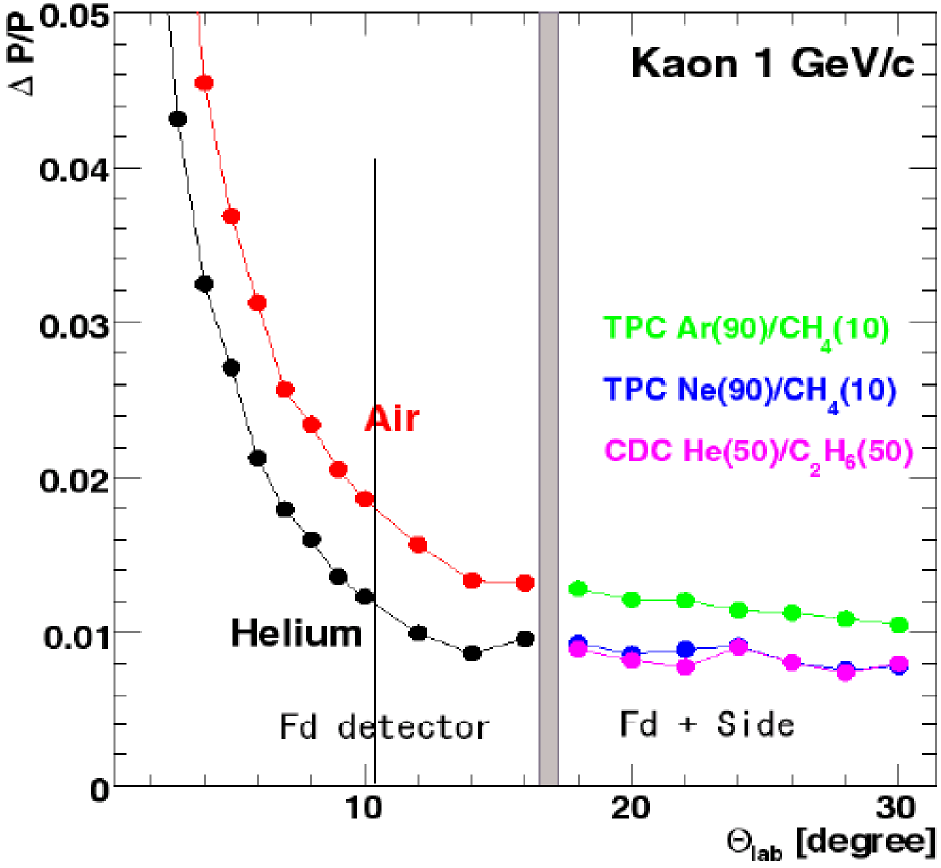
High Energy Backward Compton Photons



Backward Compton Scattering of X-ray for Ultra High Energy LEP



ΔP/P at forward region



- $2^o < \theta < 17^o$

  Vertex + Fd MWDC

  No SW tracker

  At 10 degree

  ΔP/P = 1.3% (He4 gas)

  1.9% (Air)

- $\theta > 17^o$

  MS effect in SW tracker

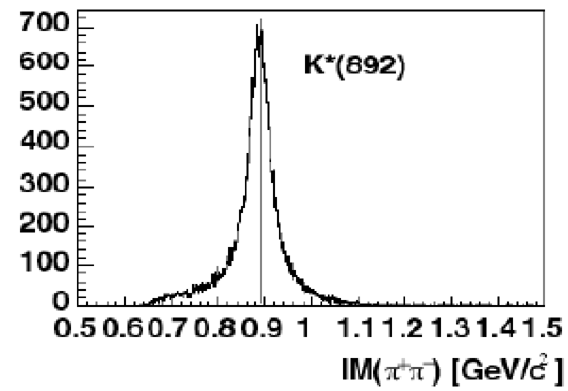
  TPC ⇒ Ar/CH_4 or Ne/CH_4

$\gamma p \rightarrow K^{*}\Lambda(1405)$

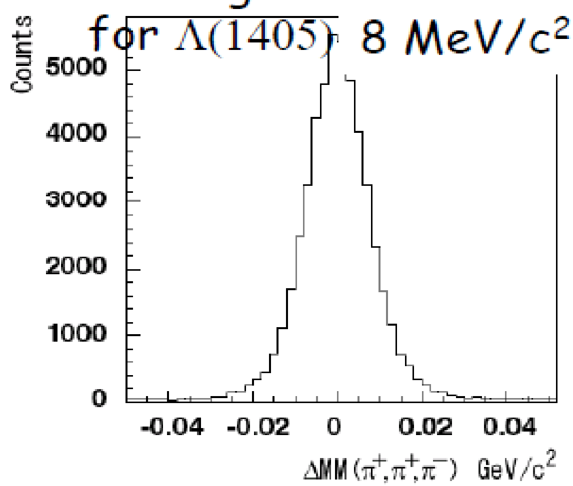
$$\gamma + p \rightarrow K^{*+} + \Lambda(1405)$$

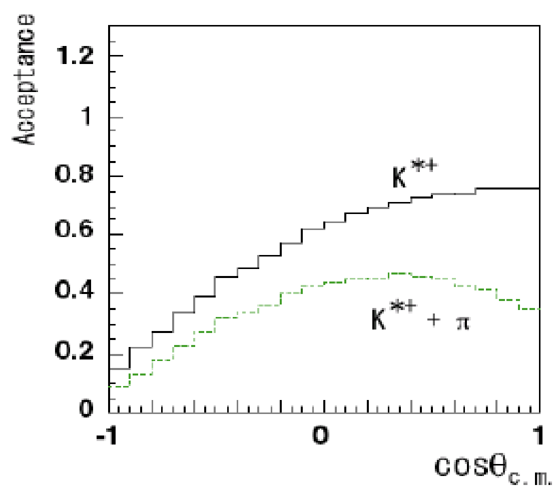
$K^{*+} \rightarrow K^0 \pi^+$, $K^0 \rightarrow \pi^+ \pi^-$

$\Lambda(1405) \rightarrow \Sigma^+ \pi^-$, $\Sigma^+ \rightarrow n \pi^+$

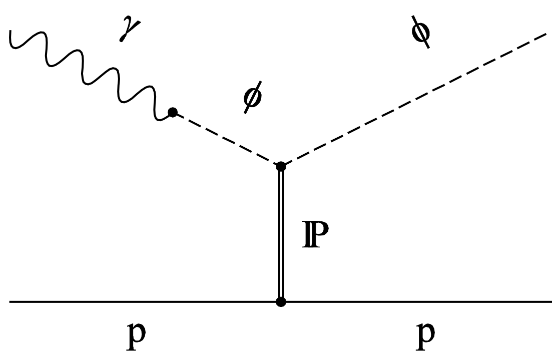


Missing mass resolution for $\Lambda(1405)$ 8 MeV/c^2

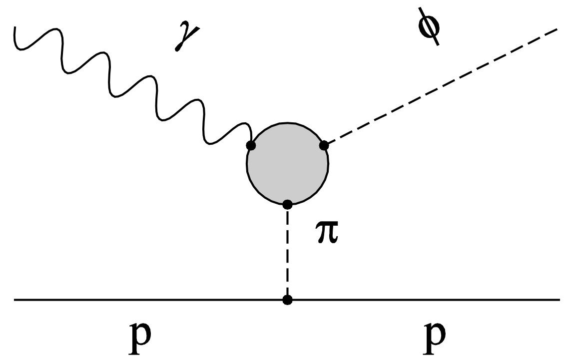




Reaction mechanisms of ϕ meson photoproduction

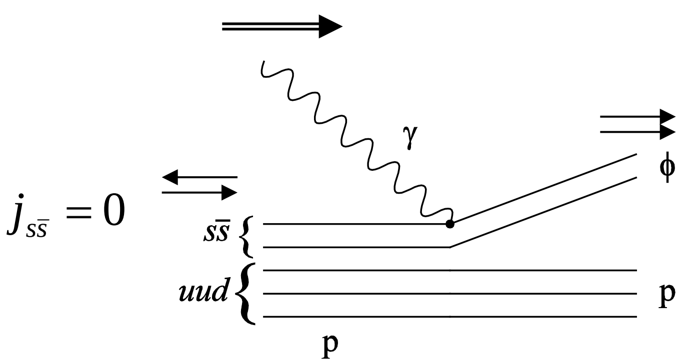


Diffractive production within the
vector-meson-dominance
model through Pomeron exchange

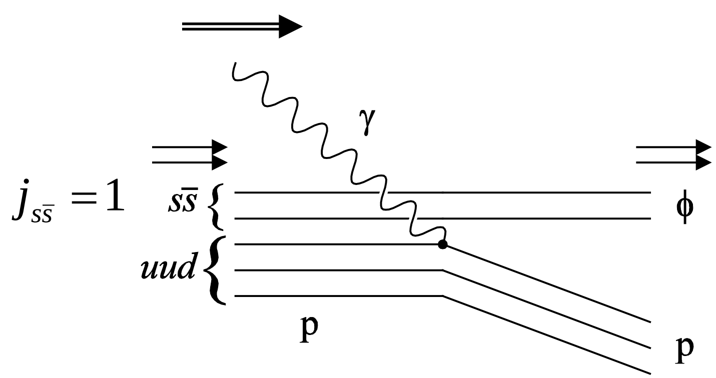


One-pion-exchange

$$| p >= A | uud > + B | uuds\bar{s} > \qquad A^2 + B^2 = 1$$



$s\bar{s}$-knockout



uud-knockout